UPPER ORDOVICIAN TRILOBITES FROM THE ZAP VALLEY, SOUTH-EAST TURKEY

by W. T. DEAN *and* ZHOU ZHIYI

Abstract. In the extreme south-east of Turkey the Şort Tepe Formation rests disconformably on Arenig strata of the highest Seydişehir Formation. Trilobites are described from the stratotype of the Şort Tepe Formation and a supplementary section, both on the north-east side of the Zap Valley, 40 km south-south-west of Hakkâri. The twenty taxa described include three new species: *Sinocybele*? *fluminis*, *Calymenesun longinasuta*, and *Paraphillipsinella pilula*. The assemblages, of early Ashgill, probably Pusgillian or possibly Cautleyan, age, consist mainly of genera widespread in Europe, Scandinavia, and Asia, but *Sinocybele*?, *Calymenesun*, and *Paraphillipsinella* have not previously been recorded outside China.

The south-eastern corner of Anatolia, known in antiquity as the Hakkâri, is a mountainous, traditionally isolated region, bounded to the east by Iran and to the south by Iraq (Text-fig. 1). It is traversed by the River Zap (known sometimes as the Great Zab) which rises near the Iranian border, flows south-west and then south in the vicinity of the towns of Hakkâri and Çukurca, and crosses into Iraq where it forms a tributary of the River Tigris.

Between Hakkâri and Çukurca the Zap cuts a deep valley to expose two inliers of Cambrian and Ordovician sediments, mostly clastics, that form part of the Arab Platform. Until recently the only available account of the Lower Palaeozoic strata was that of Altinli (1963, pp. 60–61), who divided the pre-Devonian rocks into two parts, of Cambrian(?) and Silurian(?) age; the latter, over 1000 m thick and termed Giri Formation, were said to contain *Cruziana*, possibly of Ordovician age. The latter record led Dean (1980, p. 7) to suggest that, by comparison with the Taurus Mountains, the term Seydişehir Formation should be used in place of Giri Formation. Following initial reconnaissance work, the region was re-mapped by the Turkish Petroleum Corporation (TPAO), whose maps formed the basis of a reassessment of the Cambrian and Ordovician stratigraphy by Dean *et al.* (1981). The Lower Palaeozoic rocks were noted briefly by Janvier *et al.* (1984, p. 148, fig. 1), whose account included TPAO's map showing the two inliers to represent the cores of east–west folds, the larger, northerly one termed the Zap anticline, and the other the Çukurca anticline. In Dean *et al.* (1981) it was demonstrated that shales and sandstones of Upper Cambrian and lower Ordovician age represented the Seydişehir Formation, described from the western Taurus Mountains but widespread in the eastern Taurus, south-eastern Turkey, and neighbouring parts of Iraq. Disconformably overlying strata, mainly shale, mudstone, and quartzite with very minor limestone, were named the Şort Tepe Formation and shown to be of Ashgill age.

STRATIGRAPHY AND FOSSIL LOCALITIES

a. Section at Şort Tepe.

The type section of the Şort Tepe Formation is located at the eponymous hill, 7·5 km north-west of Çukurca, where the disconformable junction with the underlying Seydişehir Formation is exposed high on the north-east side of the Zap Valley (text-fig. 1). The line of contact is sharp and planar, with no irregularity or conglomerate at the base of bed a (text-fig. 2), 30 cm of grey oolitic limestone in which no macrofossils were found. Bed b, grey shale 1 m thick, proved sparsely fossiliferous, yielding only a few small brachiopods (*Aegiromena*? sp.) and fragments of diplograptid graptolites, but no trilobites. No macrofossils of any kind were found in the 1·5 m of bioturbated,

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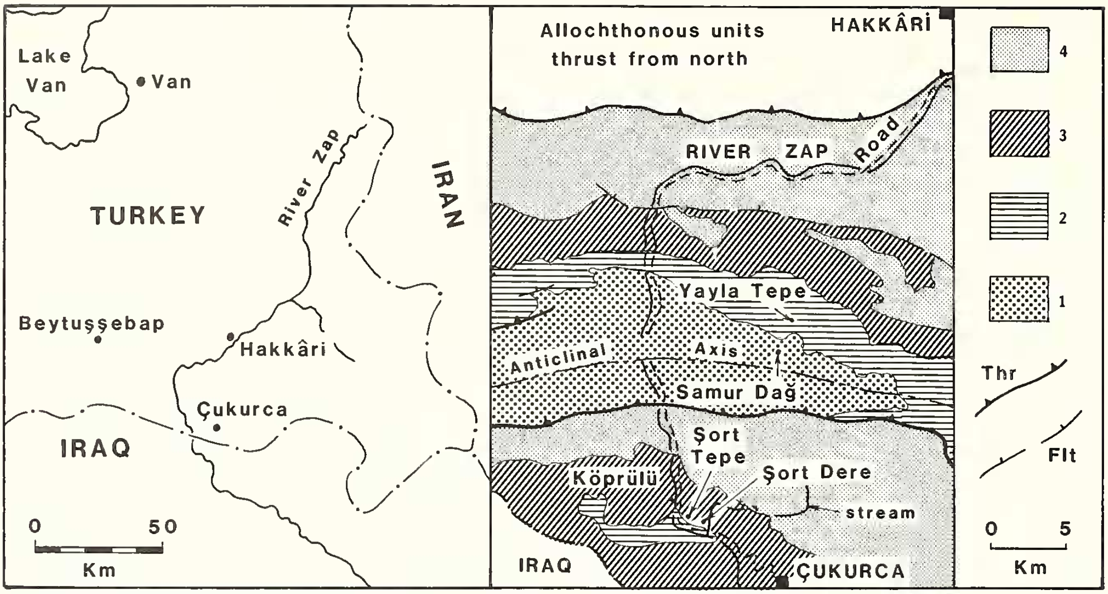


TEXT-FIG. 1. Left: sketch map of south-eastern Turkey, showing principal place-names. Right: geological map (after TPAO) of the Zap Valley between Hakkâri and Çukurca. 1 = Zabuk and Sadan formations, undifferentiated (Cambrian); 2 = Koruk, Seydişehir, and Şort Tepe formations, undifferentiated (Cambrian, Ordovician); 3 = Upper Palaeozoic rocks (undifferentiated); 4 = Mesozoic and Tertiary rocks (undifferentiated); Thr = thrust; Flt = fault.

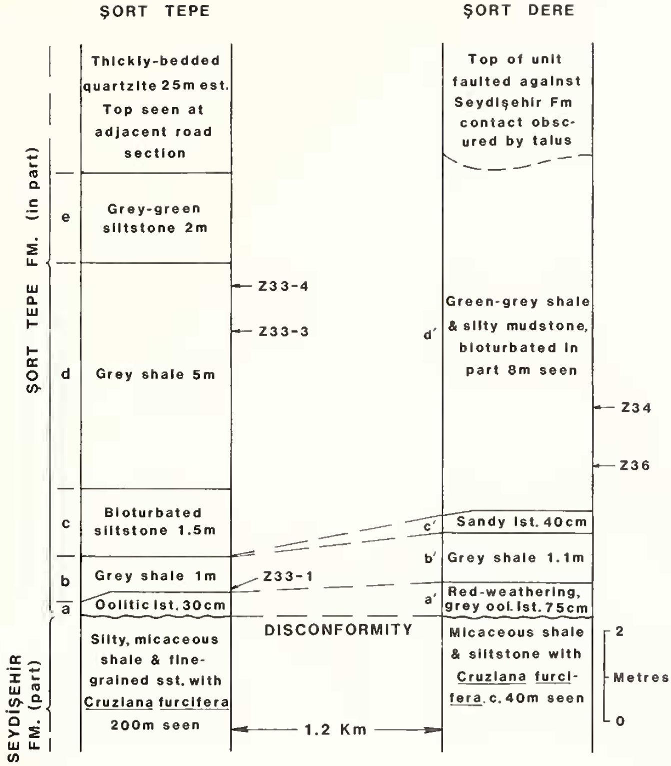
grey siltstone that make up bed c. The most varied assemblages at this section came from bed d, grey shale 5 m thick in which trilobites were found at two levels (locs. Z.33-3, Z.33-4), though much less abundantly than at Şort Dere.

The 2 m of grey-green siltstone of bed e mark a transition from the shale of bed d to a succession of resistant quartzites, mostly thickly bedded but some finely laminated, that are grey-green when fresh but weather to form a distinctive, whitish feature in the hillside. In the higher part of the measured section a small fault, with downthrow to the north-east, cuts the quartzites, whose outcrop continues north-westwards to the adjacent road, where a succession 25 m thick was seen. Silurian rocks are unknown from the area and Devonian strata overlie both Seydişehir and Şort Tepe formations with low angular unconformity in the vicinity of Köprülü, north-west of Şort Tepe (text-fig. 1; see also Janvier *et al*., 1984, pp. 149–151).

Faunal lists: Z.33-1. *Aegiromena*? sp., fragments of diplograptid graptolites; Z.33-3. *Lonchodomas* sp., *Dindymene*? sp., *Prionocheilus* cf. *obtusus*; Z.33-4. *Dindymene*? sp., *Calymenesun altinasuta*, *Birmanites latus*.

b. Section at Şort Dere

About 1·5 km south-east of Şort Tepe the small valley of Şort Dere intersects the east bank of the River Zap. Approximately 200 m north-east of the intersection, the base of the Şort Tepe Formation rests disconformably on silty shale and quartzite of the Seydişehir Formation, 40 m of which were seen between this point and the Zap. The succession (text-fig. 2), which differs in detail from that at Şort Tepe, is more accessible and better exposed but much less complete and so was used to supplement the stratotype. Again, the interformational boundary is planar, but in this case the basal unit, bed a′, is a high energy grainstone, 75 cm thick, ferruginous and oolitic, containing reworked quartzitic fragments derived from the Seydişehir Formation (Monod in Dean *et al*. 1981, p. 277). No macrofossils were found in the two succeeding units, beds b′ and c′, comprising, TEXT-FIG. 2. Measured sections in the Şort Tepe Formation showing stratigraphic positions of fossil localities.



respectively, 1·1 m of grey shale and 40 cm of sandy limestone, but bed d′ yielded numerous specimens at two levels, Z.34 and Z.36. The rocks are mainly brown-weathering, green-grey shale and silty mudstone, often exhibiting bioturbation; 8 m were seen and the highest beds are faulted against Seydişehir Formation, though the contact is masked by rock falls. Most of the fossils were found at loc. Z.34, the great majority of them trilobites, with a few poorly preserved brachiopods and sporadic machaeridian plates and echinoderm debris. All but one (Pl. 62, fig. 8) of the trilobites were disarticulated, and most came from a layer 5 cm thick, though Z.34 is taken here to include also material from the overlying 40 cm of sediment. The assemblage proved to be diverse, and the asaphinid *B. latus*, the largest form present, was easily the most abundant.

Faunal lists: Z.34. *Ampyx*? sp., *Lonchodomas* sp., *Raphiophorus*? sp., *Hibbertia* sp., *Sinocybele*? *fluminis*, *Ovalocephalus tetrasulcatus*, *Duftonia* sp., *C. longinasuta*, *P.* cf. *obtusus*, *Paraphillipsinella pilula*, *B. latus*, *Harpidella* sp., *Phorocephala* sp., *Amphitryon*? sp., *Lichas* aff. *laciniatus*, *Dicranopeltis* sp., *Diacanthaspis* sp., *Miraspis* sp.; Z.36. *Lonchodomas* sp., *Dindymene*? sp., *Paraphillipsinella pilula*, *Amphitryon*? sp., *Stenopareia* sp.

AGE AND RELATIONSHIPS OF THE TRILOBITES

During recent years it has become increasingly apparent that many Ordovician trilobite genera once thought to have a limited vertical distribution within the system have, in fact, very long ranges, and that their lateral distribution may be restricted by changes in facies. These comments apply to at least eight trilobites of the Şort Tepe Formation, assessment of whose age depends heavily on only a few genera and species. For present purposes the trilobites are divided into three groups: *a*, genera and species restricted to the Ashgill Series, though sometimes widely distributed;

b, genera with a longer stratigraphic range but previously reported only from China; and *c*, genera with both long stratigraphic range and wide geographic distribution.

Group a. Duftonia was described first from the Pusgillian Stage, lowest Ashgill Series, of northern England but has been recorded from the higher Ashgill (pre-Hirnantian) in Wales and Bohemia (Králův Dvůr Formation), though not from the Caradoc or the Silurian.

Birmanites as now interpreted (see Zhou *et al.* 1984, p. 17 for synonymy) has a long vertical range, from Tremadoc to Ashgill. *B. latus* is known only from the Ashgill of Västergötland, Sweden, where it occurs in the Red *Tretaspis* Mudstones, strata equated by Kielan (1960, p. 78) with the combined zones of *Eodindymene pulchra* and of *Staurocephalus clavifrons* in the lower and middle portions of the Polish Ashgill. In Scania, southern Sweden, a zone of *Opsimasaphus* (now *B.*) *latus* and *Dicellograptus complanatus* was employed by Glimberg (1961, p. 83). Jaanusson (1963, pp. 163, 164) equated the *O. latus* Zone with the *E. pulchra* Zone, and the *D. complanatus* Zone with the lower half of his Jerrestad Stage (subsequently termed Jerrestadian, Jaanusson 1982, p. 8), underlain by the *Pleurograptus linearis* Zone.

Ovalocephalus tetrasulcatus was described (as *Hammatocnemis*) from the *S. clavifrons* Zone of the Ashgill in Poland (Kielan 1960, p. 141) and has not been reported elsewhere in Europe. The record from the Şort Tepe Formation increases considerably the geographic distribution of the species, but the genus already had an extended history in China, where it occurs from the Arenig to the Ashgill (Lu and Zhou 1979).

Although the Turkish specimens of *Lichas* are specifically undeterminable, species assigned to the genus by Tripp (1958, p. 575) occur only in the Ashgill and the lower and middle Silurian. *Dicranopeltis* is not recorded below the Ashgill, in which it is poorly represented, and also includes several species from the Middle and Upper Silurian (Tripp 1958, p. 575).

Group b. Three genera are of particular interest as they are unrecorded from Europe but are well represented in China where, however, their vertical range extends far below the Ashgill. The type species of *Calymenesun* came from the Shihtzupu Formation (Llandeilo Series) of Guizhou Province, but the genus is recorded also from low in the Ashgill (Zhou *et al.* 1984, p. 29).

Paraphillipsinella (see review in Zhou and Dean 1986, p. 767) was founded on material from the Caradoc of Sichuan Province but occurs also in the lower Ashgill of the Yangtze region.

The generic position of trilobites here termed *Sinocybele*? is uncertain but closest comparison is with Chinese species, all of which have three pairs of pygidial pleurae in contrast to four pairs in European and Scandinavian species of the possibly related *Atractopyge*.

Whether *Amphitryon*? should also be included in group b is debatable. The genus is recorded from the higher Caradoc and the Ashgill Series in Europe, but species in which the preglabellar field of the cranidium is triangular in plan have been described only from China, where the character occurs much earlier, in the Llanvirn, and may merit generic recognition.

Group c. Remaining genera in the Şort Tepe Formation contribute no precise evidence of age. Of the Raphiophoridae, *Ampyx* and *Lonchodomas* extend from Arenig to Ashgill. The range of *Raphiophorus* is uncertain; the type species came from the Black *Tretaspis* Shale, approximately late Caradoc, of Sweden but the genus is well represented in the Ashgill and Silurian (species listed by Thomas 1978, p. 53). A supposedly Arenig species was excluded by Thomas, and *Raphiophorus* sp. from the Meadowtown Beds (upper Llandeilo or lowest Caradoc) of Shropshire (Whittard 1955, p. 23, pl. 2, figs. 13–16) comprises poorly preserved meraspids of uncertain position. *Hibbertia* occurs in both Caradoc and Ashgill, and dindymeninids have a long range within the Ordovician. *Harpidella* ranges from Ashgill to lower Devonian (Thomas and Owens 1978, p. 72), and species of *Phorocephala* that lack a preglabellar field are reported from both Caradoc and Ashgill (Zhou and Dean 1986, p. 751). The single cranidium of *Stenopareia* sp. is of little significance and *Prionocheilus* cf. *obtusus*, though closely resembling an Ashgill species from Britain and Sweden, represents a genus that changed relatively little during the Ordovician and whose oldest representatives occur in the lower Arenig of southern France (Dean 1966, p. 300). Odontopleurids constitute only a minor element in the Şort Tepe assemblages and *Diacanthaspis* is known from both Caradoc and Ashgill strata; *Miraspis* has a long range, from lower Ordovician to upper Silurian in Europe (Bruton 1968, p. 42).

To summarize, evidence given in group a favours a lower Ashgill age, corresponding to the lower half of the Jerrestadian Stage in terms of the Swedish succession and the *Dicellograptus complanatus* Zone in terms of the standard British graptolite zones. Correlation of the Ashgill stages with corresponding graptolite zones is imprecise, but according to Williams *et al.* (1972) the *D. complanatus* Zone falls within approximately the upper half of the Pusgillian, though no distinctively Pusgillian trilobites were found in the Şort Tepe assemblages. Although *B. latus* and *O. tetrasulcatus* occur together in the Şort Tepe Formation, the latter species is found slightly higher (*Staurocephalus clavifrons* Zone) in Poland, so it is possible the Turkish strata may extend above the *D. complanatus* Zone, into the Cautleyan Stage.

The relationship of the Şort Tepe Formation to successions elsewhere in south-eastern Turkey is not yet established, but the rocks may represent a continuation of the transgressive sequence, represented by the Bedinan Formation, that began in the middle Caradoc and persisted probably into the Ashgill in the Derik–Mardin region, 320 km west of Çukurca (Dean *et al.* 1981, p. 278).

SYSTEMATIC DESCRIPTIONS

Terminology is essentially that used in the *Treatise on Invertebrate Paleontology* (Harrington *et al.* in Moore 1959, pp. O117–O126), with the addition of eye socle (Shaw and Ormiston 1964) and baccula (Öpik 1967). Stratigraphic position of fossil localities at Şort Tepe and Şort Dere is shown in text-fig. 2. Figured and cited specimens are deposited in the Department of Palaeontology, British Museum (Natural History), London, and their numbers carry the prefix It.

Family RAPHIOPHORIDAE Angelin 1854
Genus AMPYX Dalman 1827

Type species. *Ampyx nasutus* Dalman 1827, *Asaphus* Limestone (upper Arenig) of Västanå, Östergötland, Sweden.

Ampyx sp.

Plate 58, figs. 2?, 8?, 9

Figured specimens. It. 19494 (Pl. 58, fig. 2), It. 19497 (Pl. 58, fig. 8), It. 19499 (Pl. 58, fig. 9).

Locality. Şort Dere, Z.34.

Description and discussion. The pygidium resembles that of *A. nasutus*, refigured by Whittington (1950, pl. 74, figs. 3–9), but is slightly shorter and the anterior pleural furrows are almost straight. The cranidium is slightly crushed but the shape of the glabella is generally similar to that of *A. nasutus* in having three pairs of depressed muscle scars on the glabellar flanks, and in the form of the anterior border, defined by a shallow border furrow that is continuous with the axial furrows. It differs from *A. nasutus* in having the anterior branches of the facial suture less convergent forwards. In all these characters the Turkish species is comparable with *A. abnormalis* Yi (1957, p. 557, pl. 5, fig. 3*a*–*e*; Lu 1975, p. 414, pl. 39, figs. 5–11; pl. 40, figs. 1–7), from the upper Arenig to Llandeilo of western Hubei, China, but the pygidium of the latter has a narrower, more gently tapered axis and the pleural regions have four pairs of pleural furrows. Records of *Ampyx* from Ashgill strata are rare and the Turkish material may represent a new species, but is too poorly preserved for formal description.

Genus LONCHODOMAS Angelin 1854

Type species. *Ampyx rostratus* Sars 1835, *Ampyx* Limestone, 4aβ (Llandeilo or lowest Caradoc) of Bygdoy, Oslo, Norway.

Lonchodomas sp.

Plate 58, figs. 5, 6, 11

Figured specimens. It. 19495 (Pl. 58, fig. 5), It. 19496 (Pl. 58, fig. 6), It. 19498 (Pl. 58, fig. 11).

Localities. Şort Tepe, Z.33-3; Şort Dere, Z.34 and Z.36.

Description and discussion. The incomplete, slightly compressed cranidium is characterized by the wide (tr.) triangular outline, the short (sag.) anterior projection of the glabella, and the slight curvature, abaxially concave, of the axial furrows. These features suggest comparison with *L. tecturmasi* (Weber 1932, p. 6, pl. 4, fig. 43; 1948, p. 18, pl. 2, figs. 20–22, 26; Chugaeva 1958, p. 32, pl. 2, figs. 3–5) from the Anderken Horizon (Caradoc) of the Chu-Ili Mountains, Kazakhstan and *L. jiantsaokouensis* Lu (1975), p. 421, pl. 41, figs. 11 and 12) from the Jiantsaokou Formation (low Ashgill) of northern Guizhou, China. But the Turkish specimen is inadequate for reference to either of these species.

L. portlocki (Barrande 1846, p. 9; 1852, p. 636, pl. 30, figs. 24–28; Olin 1906, p. 69, pl. 4, figs. 5–8; Kielan 1960, p. 169, pl. 33, fig. 8; pl. 35, fig. 4), from the Ashgill of Bohemia, Sweden, and Poland, also bears some resemblance to the Turkish form, but is distinguished by its narrower (tr.) cranidium and what appears to be a slightly depressed preoccipital lobe.

Genus RAPHIOPHORUS Angelin 1854

Type species. Raphiophorus setirostris Angelin 1854, Lower *Tretaspis* Shale (Ashgill) of Draggå bro, Dalarne, Sweden.

Raphiophorus? sp.

Plate 58, figs. 1, 3, 4, 7

Figured specimens. It. 19490 (Pl. 58, fig. 1), It. 19491 (Pl. 58, fig. 3), It. 19492 (Pl. 58, fig. 4), It. 19493 (Pl. 58, fig. 7)

Locality. Şort Dere, Z.34.

Description and discussion. The glabella is similar to that of *R. setirostris* Angelin (see Whittington 1950, p. 553, pl. 74, figs. 1 and 2), a species in which, according to Whittington, triangular bacculae are probably present, as they are in the Turkish material. However, the wide (tr.), long (exsag.) fixigenae, the forward curvature of the distal portions of posterior border and furrow, and the short anterior projection of the glabella in front of the fixigenae distinguish the Turkish specimens from *R. setirostris.* These features suggest, rather, a comparison with the type species of *Taklamakania, T. tarimensis* W. Zhang (1979, p. 1003, pl. 1, fig. 9), from the Engou Formation (Caradoc) of Keping, Xinjiang, China. A specifically identical specimen from the same locality and horizon was later described as a new genus and species *Xinjiangia yinganensis* T. Zhang (1981, p. 199, pl. 74, fig. 11). However, *Taklamakania* has a larger, longer pygidium than *Raphiophorus* and its thorax comprises only three segments. The pygidium of the Turkish species generally resembles that

EXPLANATION OF PLATE 58

Figs. 1, 3, 4, 7. *Raphiophorus*? sp. Loc. Z.34. 1, cranidium, It. 19490, ×5·5. 3, cranidium, It. 19491, ×6. 4, cranidium, It. 19492, ×5·5. 7, pygidium, It. 19493, ×8.

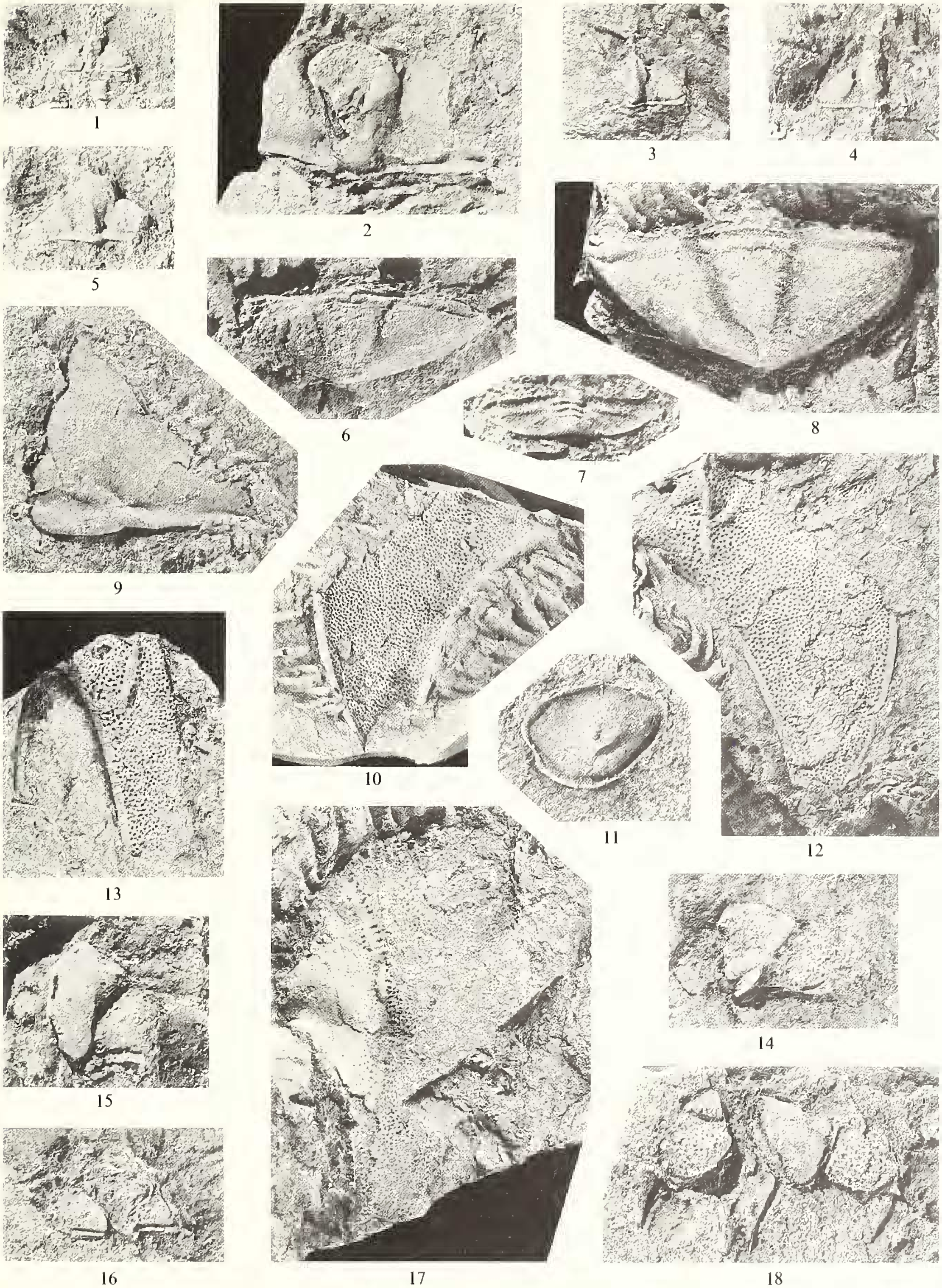
Figs. 2 and 8. *Ampyx*? sp. 2, cranidium, It. 19494, ×5, loc. Z.36. 8, pygidium, It. 19497, ×5, loc. Z.34.

Figs. 5, 6, 11. *Lonchodomas* sp. 5, cranidium, It. 19495, ×6, loc. Z.34. 6, pygidium, It. 19496, ×4, loc. Z.33-F.3. 11, hypostoma, It. 19498, ×6, loc. Z.36.

Fig. 9. *Ampyx* sp. Loc. Z.34. Cranidium, It 19499, ×5.

Figs. 10, 12, 13, 17. *Hibbertia* sp. Loc. Z.34. 10, dorsal surface of left genal prolongation, It. 19500, ×3·5. 12, ventral surface of left genal prolongation, It. 19501, ×4. 13, ventral surface of left genal prolongation, It. 19502, ×4. 17, part of right genal region of cranidium, It. 19503, ×3·5.

Figs. 14–16, 18. *Dindymene*? sp. 14, cranidium, It. 19504, ×5·5, loc. Z.33-4. 15, cranidium, It. 19505, ×6, loc. Z.36. 16, cranidium, It. 19506, ×5, loc. Z.33-3. 18, cranidium, It. 19507, ×6, loc. Z.33-3.



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of *Raphiophorus* but has three distinct axial rings, traces of a fourth ring, and three pairs of wide (exsag.) pleural furrows. In *R. setirostris* there are two axial rings and one well-defined pair of pleural furrows.

Family HARPETIDAE Hawle and Corda 1847
Genus HIBBERTIA Jones and Woodward 1898

Type species. Harpes flanaganni Portlock 1843, Bardahessiagh Beds (early Caradoc) of Pomeroy, County Tyrone, Northern Ireland.

Hibbertia sp.

Plate 58, figs. 10, 12, 13, 17; Plate 59, fig. 1

Figured specimens. It. 19500 (Pl. 58, fig. 10), It. 19501 (Pl. 58, fig. 12), It. 19502 (Pl. 58, fig. 13), It. 19503 (Pl. 58, fig. 17), It. 19508 (Pl. 59, fig. 1).

Locality. Şort Dere, Z.34.

Description and discussion. The specimens exhibit a uniformly very wide brim with large genal prolongations that narrow gently posteriorly, features suggestive of *Hibbertia*. The cheek roll is narrow, widens slightly medially, and is well defined by the distinct girder, which dies out before reaching the posterior margin. The remains of the glabella suggest that it was slightly pointed frontally. The eye ridge is narrow and the ala depressed, defined by a distinct alar furrow as in *H. sanctacrucensis* Kielan (1960, p. 157, pl. 34, figs. 4 and 6; pl. 35, fig. 8), from the Ashgill Series, *S. clavifrons* Zone, of Brzezinski, Poland. The fringe is finely and densely pitted with small pits of almost uniform size, and the cheek is covered with radiating, anastomosing ridges.

Family ENCRINURIDAE Angelin 1854
Subfamily CYBELINAE Holliday 1942
Genus SINOCYBELE Sheng 1974

Type species. Sinocybele baoshanensis Sheng 1974, Lower Pupiao Formation (Llandeilo to Caradoc Series), south of Shihtien, western Yunnan, China.

Sinocybyle? *fluminis* sp. nov.

Plate 59, figs. 2–6, 7?, 8, 9

Diagnosis. Sinocybele? species with four pairs of large tubercles sub-equispaced along median area of glabella. Palpebral lobes sited opposite posterior half of 2p glabellar lobes and about midway between glabella and lateral border furrow. Posterior branches of facial suture are very slightly curved, convex forwards, and meet the margin just in front of genal angles. Strongly developed eye ridges end opposite 3p furrows. Pygidium with three pairs pleurae that curve strongly backwards

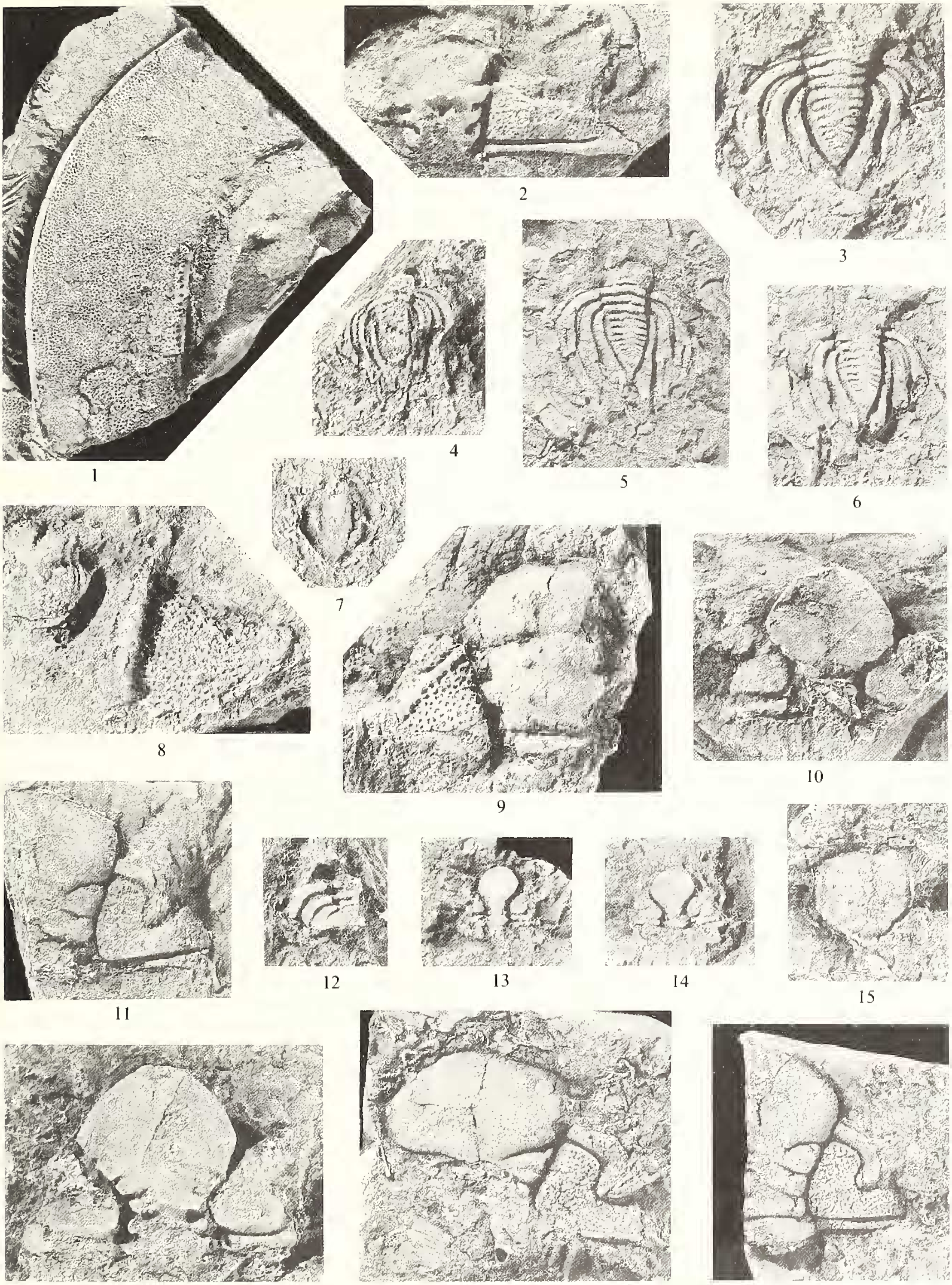
EXPLANATION OF PLATE 59

Fig. 1. *Hibbertia* sp. Loc. Z.34. Ventral surface of cephalic fringe, It. 19508, ×3.

Figs. 2–6, 7?, 8, 9. *Sinocybele*? *fluminis* sp. nov. Loc. Z.34. 2, cranidium, It. 19509, ×5. 3, pygidium, It. 19510, ×5. 4, pygidium, It. 19511, ×6. 5, pygidium, It. 19512, ×5. 6, pygidium, It. 19513, ×5. 7, hypostoma referred questionably to species, It. 19514, ×6. 8, left librigena with associated pygidium of *Paraphillipsinella*, It. 19515, ×5. 9, cranidium, It. 19516, ×5. 5 is holotype; remainder (excluding fig. 7) are paratypes.

Figs. 10, 12–16. *Ovalocephalus tetrasulcatus* (Kielan 1960). Loc. Z.34. 10, cranidium, It. 19477, ×5. 12, pygidium, It. 19517, ×5. 13, cranidium, It. 19478, ×6. 14, cranidium, It. 19518, ×6. 15, hypostoma, It. 19519, ×5. 16, cranidium, It. 19520, ×5.

Figs. 11, 17, 18. *Duftonia* sp. Loc. Z.34. 11 and 18, internal mould and latex cast of cranidium, It. 19521, ×3·5. 17, cranidium, It. 19522, ×3.



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to end in long free points. Axis subtriangular with three complete and about nine partially defined axial rings.

Holotype. It. 19512 (pl. 59, fig. 5).

Paratypes. It. 19509 (Pl. 59, fig. 2), It. 19510 (Pl. 59, fig. 3), It. 19511 (Pl. 59, fig. 4), It. 19513 (Pl. 59, fig. 6), It. 19515 (Pl. 59, fig. 8), It. 19516 (Pl. 59, fig. 9).

Locality. Şort Dere, Z.34.

Description. The more complete of the two paratype cranidia has an estimated overall breadth (excluding fixigenal spines) of 11·6 mm and an estimated length of 3·7 mm. Even allowing that the specimen is dorsally compressed, the long (tr.), acutely triangular outline of the posterior areas of the fixigenae is noteworthy. The combined glabella and preglabellar field is about as broad as long, its outline broadening slightly so that the basal breadth is 0·8 of the frontal. The boundary between glabella and preglabellar field is indicated by a pair of short (tr.), shallow grooves (Pl. 59, fig. 2) that run adaxially forwards from the axial furrows. Three inequisized pairs of lateral glabellar lobes, 1p the smallest, are separated by short (tr.), deep lateral furrows, the 1p pair of which turn backwards adaxially so that the 1p lobes are of 'cat's ear' outline, linked to the median area by narrow necks. Most of the glabella, if not all, is covered with fine granules. In addition there are four pairs of large tubercles, subequally spaced longitudinally and sited opposite the rear half of the 2p lobes, the centre of the 3p lobes, and then at almost equal intervals between the 3p lobes and the anterior border. The last named is low, well defined by a broad (sag.) anterior border furrow, and carries about six (estimated) large tubercles dorsally; it is incompletely preserved medially and the presence of a median projection has not yet been demonstrated.

The more complete cranidium shows the anterior branches of the facial suture to be straight, converging forwards slightly from eyes that are sited opposite the 1p glabellar furrows and approximately midway between the axial furrows and the lateral border furrow. The eye lobes are joined to the axial furrows opposite the 3p glabellar furrows by strongly developed, smooth eye ridges. One of the latter is better seen in the second paratype cranidium (Pl. 59, fig. 9), in which, owing to crushing, it appears to be directed more strongly backwards.

A single left librigena (Pl. 59, fig. 8) shows the eye to be small, possibly pedunculate, and the lateral border well defined; the pitted surface carries a few large tubercles like those on the lateral border.

The pygidium bears a marked general resemblance to that of *Atractopyge* Hawle and Corda 1847 (for examples, see Dean 1971 and Ingham 1974), the most obvious difference being that in *S.? fluminis* the pleural regions are composed of three pairs of pleurae instead of four. The outline of the axis is subtriangular, slightly constricted at the third ring furrow, and apparently ends in a sharp point that represents, in fact, the post-axial ridge, set slightly below the parabolic, diminutive, true terminal piece (Pl. 59, figs. 5 and 6). The first three ring furrows are complete but subsequent furrows (nine, possibly ten are visible) are incomplete both immediately adjacent to the axial furrows and medially, where a smooth median band occupies the axial third of the axis. Three pairs of pleurae that end in long free points curve strongly backwards and inwards so that the third pair almost meet behind the axis, where they are separated by the small post-axial ridge. Each pleura is divided by a distinct pleural furrow into unequal anterior and posterior bands, the latter about twice as wide (tr.) as the former. Anterior bands are clearly visible on the first two pairs of pleurae but scarcely or not at all on the third pair, so that the second and third pairs of posterior bands appear to be separated by a single furrow, in which a row of granules may be visible. Surface of the pygidium is granulose.

The hypostoma of *S. baoshanensis* remains undescribed and the present small specimen (Pl. 59, fig. 7) is therefore assigned only questionably to the new species. It is of encrinurid type and its outline (excluding anterior wings) is suboval, with maximum breadth 2·0 mm. and median length 2·5 mm. The anterior two-thirds of the middle body are divided into three longitudinal lobes by a pair of straight, parallel furrows. The central lobe so formed occupies just over half the breadth of the middle body and projects forwards of it; in life position it would have underlain the centre of the anterior border. Temple (1954, p. 318) suggested that in *Encrinurus* the generally comparable central lobe may have accommodated the ventral surface of the pygidium during enrolment and the present specimen may have functioned similarly. The middle body is circumscribed by a narrow, rim-like border that broadens to form the incompletely preserved anterior wings.

Discussion. S. baoshanensis Sheng (1974, p. 110, pl. 7, fig. 6*a*, *b*) was founded on a single cranidium, illustrated as both internal and external moulds, of cybelinid type in which the anterior border was produced forwards to form a prominent, flat-topped, horn-like protuberance whose length, though incomplete, was at least two-thirds that of the glabella. Three, possibly four, pairs of large tubercles are visible on the central area of the glabella and the remainder of the surface is covered with small tubercles.

Zhou *et al.* (1984, p. 27), in discussing the relationships of *Cybelurus*? from the Shihtzupu Formation in Guizhou Province, noted that *Sinocybele* has branching 3p glabellar furrows like *Cybelurus* and that if the pygidium of *Sinocybele* proves to have three pairs of pleurae, their *Cybelurus*? sp. would be assignable to *Sinocybele* even though the anterior cranidial projection is only small. *A. sinensis* Lu (1975, pp. 233, 444, pl. 45, figs. 15 and 16), from the Shihtzupu Formation of Zunyi and based on a single cranidium, was assigned to *Cybelurus*? by Zhou *et al.* (1984, p. 27). The holotype has long (tr.), acutely triangular, postocular fixigenae generally similar to those of *S. fluminis*, but the eyes of *sinensis* (here also placed questionably in *Sinocybele*) are set very far back, opposite the 1p glabellar lobes; both species have the fixigenal spines directed only slightly backwards. *S.*? *sinensis* has five pairs of large tubercles on the median area of the glabella, and there are additional, paired tubercles on the abaxial parts of the combined frontal glabellar lobe and preglabellar field.

Subfamily DINDYMENINAE Henningsmoen in Moore 1959
Genus DINDYMENE Hawle and Corda 1847

Type species. Dindymene fridericiaugusti Hawle and Corda 1847, from the Králův Dvůr Formation (Ashgill Series), Králův Dvůr, Czechoslovakia.

Dindymene? sp.

Plate 58, figs. 14–16, 18

Figured specimens. It. 19504 (Pl. 58, fig. 14), It. 19505 (Pl. 58, fig. 15), It. 19506 (Pl. 58, fig. 16), It. 19507 (Pl. 58, fig. 18).

Localities. Şort Tepe, Z.33-3 and Z.33-4; Şort Dere, Z.36.

Description and discussion. The Turkish specimens, inadequate for specific determination, comprise mostly fragments of cranidia, though one piece of shale (It. 16063, not illustrated) shows vestiges of a partly disarticulated thorax and pygidium of dindymeninid type, the pleural tips extended to form long, slim spines. The posterior border and border furrow are narrow, transversely straight, and the genal angles are produced to form fixigenal spines, seen in It. 19507. The same specimen shows a broken spine, *c.* 2 mm long, apparently extending from the glabella, and It. 19505 (Pl. 58, fig. 15) may retain the spine base. An analogous though shorter spine is seen on some cranidia of *D. hughesiae* Reynolds 1894 (Ingham 1974, pl. 18, figs. 1, 4, 8–10), from the Ashgill (Rawtheyan) of northern England and of *D. cordai* Nicholson and Etheridge 1878 (Ingham 1974, pl. 18, fig. 18), from the Rawtheyan of Scotland; a spine base is visible on the holotype of *D. fridericiaugusti* (original of Hawle and Corda 1847, pl. 1, fig. 3; see also Horný and Bastl 1970, pl. 15, fig. 1). The remainder of the glabellar surface is smooth except for a few, widely spaced tubercles, some possibly paired. By contrast the fixigenal surface is corsely pitted, with more numerous large tubercles than on the glabella. Broadly similar ornamentation is seen on cranidia of *D. ornata* Linnarsson 1869 from Sweden and Poland illustrated by Kielan (1960, pl. 26, fig. 6; pl. 27, fig. 4), though the glabella is more granulose and has more tubercles than the Turkish species.

Family HAMMATOCNEMIDAE Kielan 1960
Genus OVALOCEPHALUS Koroleva 1959

Type species. Ovalocephalus kelleri Koroleva 1959, from the late Caradoc of northern Kazakhstan. The close resemblance of *Ovalocephalus* and *Hammatocnemis* was noted by Zhou and Dean (1986, p. 776) and the two genera are considered here as synonyms.

Ovalocephalus tetrasulcatus (Kielan 1960)

Plate 59, figs. 10, 12–16

Hammatocnemis tetrasulcatus Kielan 1960, p. 141, pl. 25, fig. 3; pl. 26, figs. 2–4; pl. 27, figs. 6–8; text-figs. 38 and 39.

Figured specimens. It. 19477 (Pl. 59, fig. 10), It. 19478 (Pl. 59, fig. 13), It. 19517 (Pl. 59, fig. 12), It. 19518 (Pl. 59, fig. 14), It. 19519 (Pl. 59, fig. 15), It. 19520 (Pl. 59, fig. 16),

Locality. Şort Dere, Z.34.

Description and discussion. All the Turkish specimens are small, but the cranidia match closely those illustrated from Poland. According to Kielan's (1960, p. 142) original account the frontal breadth of the glabella is equal to three times its breadth in front of the preoccipital segment, but her illustrations of undistorted specimens (Kielan 1960, pl. 26, fig. 4; pl. 27, fig. 6; text-fig. 38) show that it is only 2·3 times as broad. In the largest, slightly compressed, Turkish cranidia the corresponding figures are 2·2 and 2·4, and the specimens closely resemble the holotype and one paratype (Kielan 1960, pl. 26, figs. 2 and 4).

The hypostoma of *Ovalocephalus* is not well known and that of *O. tetrasulcatus* has not been described, but the present Turkish example (Pl. 59, fig. 15) is attributed to the species on account of its resemblance to the hypostoma of *O. decorus* (Lu in Lu and Chang 1974) figured by Lu and Zhou (1979, pl. 3, fig. 6). The specimen is almost as long (2·8 mm) as broad (3·0 mm), of low convexity, pentagonal in outline with the transverse anterior margin slightly convex. The subparallel lateral margins occupy 0·57 of the overall length, and the straight posterolateral margins converge to meet at an angle of 100°. A low, narrow rim runs around the lateral and posterior margins and widens (sag.) slightly to form a small point at the posterior extremity of the hypostoma.

The only available Turkish pygidium (Pl. 59, fig. 12) is very small, with an estimated breadth and median length of 4·0 mm and 1·4 mm respectively, and closely resembles the Polish examples. The axis has three distinct axial rings and a fourth is less well defined. In the Polish type material the pleural regions comprise four pairs of pleurae, the first three distinct, and four pairs of free points were said to be present, though these are not seen in all the illustrations. In the Turkish example there are three distinct pleurae plus faint traces of a fourth. First and second pleurae are bounded by broad (exsag.), deep, interpleural furrows and end in short free points; third pleurae show no free points and only the adaxial half of the third interpleural furrow is clearly defined. All three pleurae have a node developed immediately outside the axial furrow; a similar structure was described by Kielan (1960, p. 143) and evidently corresponds to nodes on the thorax (see also Lu and Zhou's illustrations 1979, pl. 4, figs. 3 and 4 of the thorax of *O. decorus* (Lu in Lu and Chang 1974)).

Present evidence suggests that *O. tetrasulcatus* has been found as yet only in Poland and south-eastern Turkey. *O. tetrasulcatus* as recorded by Lu and Zhou (1979, pl. 2, figs. 10 and 11) from the Qilang Formation (Caradoc) of Keping, Xingjiang Province, China, has since been described as *O. kanlingensis* (T. Zhang 1981, p. 209, pl. 77, figs. 5–7).

Family DALMANITIDAE Vogdes 1890
Genus DUFTONIA Dean 1959

Type species. *Duftonia lacunosa* Dean 1959, Dufton Shales (Ashgill; Pusgillian Stage) of northern England.

Duftonia sp.

Plate 59, figs. 11, 17, 18

Figured specimens. It. 19521 (Pl. 59, figs. 11 and 18), It. 19522 (Pl. 59, fig. 17).

Locality. Şort Dere, Z.34.

Description and discussion. The Turkish cranidia differ from *D. lacunosa* Dean (1959, p. 144, pl. 19, figs. 2, 5, 6, 8) in having: frontal glabellar lobe, though slightly compressed, proportionately longer, greater than half the glabellar length, compared with about half; rear ends of the eye set proportionately further from the axial furrows and opposite the mid-points of the 2p glabellar lobes, compared with opposite the 1p glabellar furrows. In the two species both the palpebral lobes and the well-defined, strongly sigmoidal palpebral furrows extend to the axial furrows, in *D. lacunosa* at points opposite the 3p glabellar furrows and anterolateral tips of the 3p lobes, and in *D.* sp. well in front of the 3p furrows. The Turkish material shows traces of a very low, thin rim that represents the anterior border, a structure scarcely discernible in *D. lacunosa*.

Dalmanites morrisiana Barrande (1852, p. 559, pl. 27, figs. 8 and 9) was assigned to *Duftonia* by Dean (1967*a*, p. 38) and the original of Barrande's fig. 8 was selected as neotype by Marek (in Horný and Bastl 1970, p. 210). *Dalmanites morrisiana*, from the Králův Dvůr Formation (Ashgill), has slightly smaller, narrower palpebral lobes than *Duftonia* sp. and these structures extend from just behind the 3p furrows to end at points relatively further from the posterior border furrow than in either *D.* sp. or *D. lacunosa*, and a greater distance from the glabella. Evidence for a median occipital tubercle in *D. lacunosa* is equivocal, but one is visible both in *D.* sp. and in Barrande's illustrations of *Dalmanites morrisiana*.

Family CALYMENIDAE Burmeister 1843
Subfamily REEDOCALYMENINAE Hupé 1955

Lu (1975, pp. 445–458) included *Reedocalymene*, *Calymenesun*, and *Neseuretus* (a senior subjective synonym of *Synhomalonotus*) in the Reedocalymeninae, with the tacit implication that Synhomalonotinae Kobayashi 1960 is a junior synonym. We follow this classification provisionally here as *Calymenesun* has several characters in common with *Neseuretus*, and we add *Vietnamia* Kobayashi 1960 and *Neseuretus* (*Neseuretinus*) Dean 1967*b*. The position of *Reedocalymene* Kobayashi 1951, with anterior projection of the frontal area still longer than that of *Calymenesun*, is less clear and the genus is in need of revision.

Genus CALYMENESUN Kobayashi 1951

Type species. *Calymene tingi* Sun 1931, Shihtzupu Formation (Llandeilo) of Feilaishi, Zunyi, Guizhou, China.

Calymenesun longinasuta sp. nov.

Plate 60, figs. 1–3, 5, 6, 8–10, 12, 13

Diagnosis. *Calymenesun* species with glabellar outline straight-sided laterally and frontally. Anterior border steeply inclined forwards, well defined by anterior border furrow that is deep abaxially but broad (sag.) and shallow medially. Median third of anterior border of cranidium is produced to form stout spine. Lateral border wide, well defined.

Holotype. It. 19527 (Pl. 60, figs. 8 and 9).

Paratypes. It. 19523 (Pl. 60, figs. 1 and 2), It. 19524 (Pl. 60, fig. 3), It. 19525 (Pl. 60, fig. 5), It. 19526 (Pl. 60, figs. 6, 10, 12, 13).

Locality. Şort Dere, Z.34.

Description. The length of the glabella is almost equal to, or slightly less than, its basal breadth; there are three inequisized pairs of lateral lobes, and glabellar outline tapers evenly to a transversely straight anterior margin. Anterior border is produced in same plane to form a frontal spine at least as long as the preglabellar field. Pedunculate palpebral lobes stand higher than glabella, and are sited opposite the 2p furrows and 3p lobes. Weakly developed eye ridges extend to the axial furrows opposite, or slightly in front of, the 3p furrows. Anterior branches of facial suture are straight and convergent. Axial furrows widen abaxially opposite the 1p lobes to accommodate a pair of small bacculae. Median occipital tubercle present. Surface, excluding furrows, is mostly granulose but the median lobe of the glabella carries five equispaced pairs of tubercles that become progressively larger from front to rear. Glabella generally resembles that of *Neseuretus* but the preglabellar field and anterior border are clearly defined, quite apart from the striking development of the anterior spine. The large, paired glabellar tubercles are particularly distinctive and the rearmost pair is visible also on the internal mould.

Paratype left librigena is of typical calymenid form but lateral border is very wide and well defined. The specimen shows the eye surface, though incomplete, to be short (exsag.), bounded by poorly defined eye socle.

The pygidium is of calymenid type, with seven axial rings and five or six pairs of furrowed ribs. Outline of axis is slightly constricted behind sixth axial ring, and postaxial ridge is apparently parallel-sided and convex as in *Neseuretus*. Pleural furrows become progressively less well defined from front to rear and do not quite attain the lateral margin. All the ribs are divided by faint interpleural furrows into two unequal bands, the anterior twice as wide (exsag.) as the posterior. About midway between axial furrow and lateral margin is a faint depression that corresponds to what Campbell (1967) termed a cincture, a coaptative structure commonly developed in calymenids.

Discussion. *C. tingi* (Sun 1931, p. 29, pl. 3, fig. 9*a–g* only, *non* 9*h*) was redescribed by Zhou *et al.* (1984, p. 29, fig. 7*a–g*, *i*, *j*) and differs from the new species in several respects: the glabella widens considerably across the 1p lobes, and the axial furrows, which contain bacculae, are strongly curved, abaxially concave, in a manner recalling that in *Vietnamia* Kobayashi (1960, p. 43); the anterior branches of the facial suture are curved; the anterior border is less distinctly defined and forms a process that extends to produce a slim spine as long as the remainder of the cranidium; the eyes are sited opposite the 2p lobes and furrows; the surface is finely granulose with no tubercles.

C. granulosa Lu (1975, pp. 238, 450, pl. 47, figs. 1–5), from the top of the Linhsiang Formation (lowest Ashgill, *Nankinolithus* Zone) at Chikangpo, Ichang district, west Hupei, China, has a proportionately shorter, broader (esp. basally) glabella than the new species; the anterior border and furrow are almost undefined; and the lateral border furrow is absent. In these respects *C. granulosa* is more comparable with *C. tingi*.

In *C. yinganensis* Zhang (1981, p. 211, pl. 78, figs. 3–5), a species previously referred to *Neseuretus* (Zhang *et al.* 1982, p. 72, table 10), from the Qilang Formation (Caradoc) of Kanling, Keping, Xinjiang Province, China, the preglabellar field and anterior border, though incomplete, appear less well defined than in the new species; they and the anterior branches of the facial suture are more comparable with those of *C. tingi*, though the latter is readily recognized by the distinctly large basal breadth of the glabella. Small, sparse tubercles with a suggestion of arrangement in transverse rows ornament the glabella of *C. yinganensis*, and the pleural regions of the pygidium show well-developed cinctures like those of *C. tingi*, but unlike the new species. *C. zhejiangensis* Ju in Qiu *et al.* (1983, p. 250, pl. 87, figs. 11 and 12), from the Huangnekhan Formation (Ashgill, *Nankinolithus* Zone) of Jiangshan, west Zhejiang Province, China, has distinct bacculae and the uniformly tapered glabellar outline is more like that of *C. altinasuta* than that of *C. tingi*, though the latter's less well-defined preglabellar field is more comparable. The pygidium of *C. zhejiangensis* is very different from that of the new species in having a broad (exsag.), deep cincture that divides the pleural regions into small, coarsely ribbed proximal and weakly ribbed distal portions, and coincides with the junction of terminal piece and post-axial ridge.

EXPLANATION OF PLATE 60

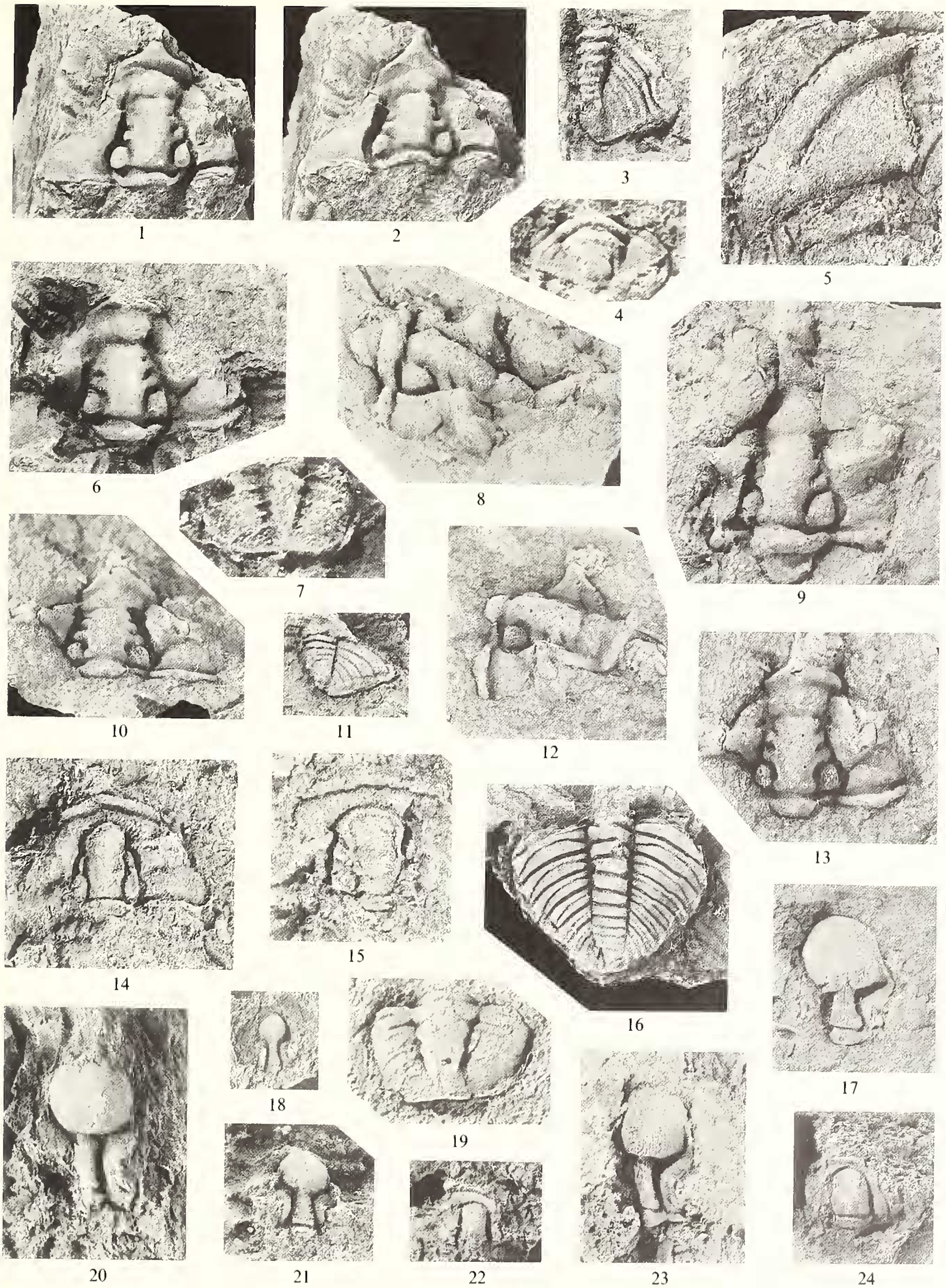
Figs. 1–3, 5, 6, 8–10, 12, 13. *Calymenesun longinasuta* sp. nov. Loc. Z.34. 1 and 2, cranidium, It. 19523, ×3. 3, pygidium, It. 19524, ×4. 5, left librigena, It. 19525, ×3. 6 (internal mould), 10, 12, 13 (latex cast), cranidium, It. 19526, ×3. 8 and 9, cranidium, It. 19527, ×4. 8 and 9, holotype; remainder are paratypes.

Figs. 4 and 24. *Phorocephala* sp. Loc. Z.34. 4, pygidium, It. 19528, ×9. 24, cranidium, It. 19529, ×5.

Figs. 7, 17–21, 23. *Paraphillipsinella pilula* sp. nov. 19 from Loc. Z.36; remainder from Loc. Z.34. 7, pygidium, It. 19530, ×8. 17, cranidium, It. 19531, ×6. 18, cranidium, It. 19532, ×6. 19, pygidium, It. 19533, ×8. 20, cranidium, It. 19534, ×6. 21, cranidium, It. 19535, ×6. 23, cranidium, It. 19536, ×6. 17 is holotype; remainder are paratypes.

Figs. 11, 14–16. *Prionocheilus* cf. *obtusus* (M'Coy 1846). Loc. Z.34. 11, pygidium, It. 19537, ×5. 14, cranidium, It. 19538, ×5. 15, cranidium, It. 19539, ×6. 16, pygidium and two, possibly three, attached thoracic segments, It. 19540, ×4.

Fig. 22. *Harpidella* sp. Loc. Z.34. Cranidium, It. 19541, ×6.



DEAN and ZHOU, Turkish Ordovician trilobites

Subfamily PHAROSTOMATINAE Hupé 1953
Genus PRIONOCHEILUS Rouault 1847

Type species. Prionocheilus verneuili Rouault 1847, from an unnamed formation of Middle Ordovician age at Poligné, Brittany, France.

Prionocheilus cf. *obtusus* (M'Coy 1846)

Plate 60, figs. 11, 14–16

Figured specimens. It. 19537 (Pl. 60, fig. 11), It. 19538 (Pl. 60, fig. 14), It. 19539 (Pl. 60, fig. 15), It. 19540 (Pl. 60, fig. 16).

Locality. Şort Dere, Z.34.

Description and discussion. M'Coy's (1846, p. 54, pl. 4, fig. 6) holotype cranidium from the Chair of Kildare Limestone in eastern Ireland was redescribed by Whittington (1965, p. 55, pl. 16, figs. 1–3, 6) and by Dean (1971, p. 42, pl. 18, figs. 10, 12, 13), who figured additional topotype material both of the species and of *Calymene leptaenarum* Törnquist 1884, placed in synonymy with it. The age of the type material is Ashgill, probably Rawtheyan Stage. Both Turkish cranidia are slightly distorted and incomplete but generally resemble the Irish material, and the anterior border and preglabellar field are similar. In both specimens the eye ridges meet the axial furrows just in front of the 2p furrows as in the holotype of *P. obtusus*, but whether the palpebral lobes are sited opposite the outer ends of the same furrows is less clear. Plate 60, fig. 14 shows the characteristic widening of the axial furrows opposite the 1p lobes to accommodate structures that have been termed, variously, *Pharostoma*-Flecke (Öpik 1937, p. 23) or paraglabellar areas (Harrington *et al.* in Moore 1959, p. O123).

In Plate 60, fig. 11 the pygidium is slightly shortened by compression but the anterior half of the axis carries four axial rings, followed by traces of a fifth; the remaining pleural region has five well-defined ribs with faint interpleural furrows, and part of a sixth rib in addition to the anterior half rib. Pygidia of *P. obtusus* from Ireland (Dean 1971, pl. 18, figs. 4, 5, 14; pl. 19, figs. 5, 10, 12) and Sweden (Warburg 1925, p. 157, pl. 4, figs. 2–4) have five or six axial rings, the last poorly defined, and five pairs of ribs. The apparently rounded tips of the ribs in the Turkish specimen are due to weathering, and are not an original feature.

The distribution of *P. obtusus* is not known in detail. Although the type material is probably of Rawtheyan age, and *P.* cf. *obtusus* from the Rhiwlas Limestone of North Wales is likely to be of similar age, it is clear that broadly comparable forms have an extended stratigraphic range and specimens from the Caradoc of Norway described by Owen and Bruton (1980, p. 32, pl. 9, figs. 10, 11, 13–15) differ only in details of ornamentation, length of preglabellar field, and the slightly more posterior position of palpebral lobes.

Xuanenia Zhou in Zhou *et al.* 1977, type species *X. granulosa* Zhou in Zhou *et al.* (1977, p. 263, pl. 79, figs. 5–7) from the Linhsiang Formation (Ashgill) of Gaoluo, Xuanen, west Hubei, China, apparently differs little from *Prionocheilus*. The anterior border is slightly less sharply defined, the front of the glabella is less broadly rounded, and the 1p and 2p lobes appear to coalesce to form composite structures bounded adaxially by longitudinal furrows. The eyes and eye ridges are situated opposite the 2p lobes and furrows, and the librigena shows a row of slim, ventrally directed spines. A possible trace of bacculae is visible in Zhou's pl. 79, fig. 5 (the holotype) but not in his pl. 79, fig. 6; similar structures are seen also in *X. splendida* Ju in Qui *et al.* (1983, p. 251, pl. 87, figs. 9 and 10), from the Huangnekang Formation (low Ashgill) of Jiande, west Zhejiang, China.

Family PHILLIPSINELLIDAE Whittington 1950
Genus PARAPHILLIPSINELLA Lu in Lu and Chang 1974

Type species. Paraphillipsinella globosa Lu in Lu and Chang 1974, Pagoda Formation (Caradoc), Chenkou, Sichuan Province, China.

Junior subjective synonym. Protophillipsinella Chen in Li *et al.* (1975, p. 155).

Discussion. A translation of the original generic diagnosis, together with minor emendations, was given by Zhou and Dean (1986, p. 766), who followed Lu and Zhou (1981, p. 14) in considering *Paraphillipsinella* to include, at that time, only two species: *P. globosa* Lu in Lu and Chang (1974, p. 133, pl. 53, figs. 8 and 9) and *P. nanjiangensis* Lu in Lu and Chang (1974, p. 133, pl. 53, fig. 10). Of the two, only *P. globosa* is regarded as sufficiently close to the new species to merit discussion, the glabella of *P. nanjiangensis* being easily recognized by its transversely suboval anterior lobe, short, squat posterior lobe, and wide fixigenae. To the previous generic criteria we now add the presence, sometimes weakly developed, of a narrow anterior border and border furrow immediately adjacent to the axial furrows. A median occipital tubercle is at least sometimes, and possibly always, present.

Paraphillipsinella pilula sp. nov.

Plate 60, figs. 7, 17–21, 23

Diagnosis. *Paraphillipsinella* species characterized by: narrow (exsag.) anterior border and border furrow well developed laterally, die out frontally; interocular portion of each fixigena narrow, little more than half width of adjacent part of posterior lobe of glabella; well-defined palpebral lobes sited opposite 2p and posterior half of 3p glabellar lobes.

Holotype. It. 19531 (Pl. 60, fig. 17).

Paratypes. It. 19530 (Pl. 60, fig. 7), It. 19532 (Pl. 60, fig. 18), It. 19533 (Pl. 60, fig. 19), It. 19534 (Pl. 60, fig. 20), It. 19535 (Pl. 60, fig. 21), It. 19536 (Pl. 60, fig. 23).

Localities. Şort Dere, Z.34 and Z.36.

Description and discussion. Rather than give a detailed description of the species, comments are confined mainly to features relevant to its recognition. Lu's illustrations of the holotype of *P. globosa* show the subspherical anterior lobe and subcylindrical posterior lobe of the glabella occupying, respectively, 0·55 and 0·28 of the overall length of the cranidium. In *P. pilula* the corresponding figures are 0·52 and 0·39 in the largest apparently undistorted cranidium but 0·47 and 0·42 in the smallest. In most published illustrations of *Paraphillipsinella* the boundary between anterior and posterior lobes often appears as a sharp, transverse furrow; but this is the result of compression and is not seen in specimens preserved in limestone (Zhou and Dean 1986, pl. 62, figs. 13–15). The anterior border and border furrow of the new species are particularly striking, with each end extending adaxially from the shallow axial furrows around the abaxial quarter of the anterior lobe. The posterior lobe is gently tapered and there are four pairs of glabellar lobes, separated by pit-like glabellar furrows; 1p lobes are slightly larger than 2p to 4p pairs and form part of weakly defined basal glabellar segment. Straight eye ridges run from anterior ends of palpebral lobes to meet axial furrows opposite 4p glabellar lobes. The position of the palpebral lobes in *P. globosa* is difficult to distinguish in published illustrations (Lu in Lu and Chang 1974, pl. 53, figs. 8 and 9) but is probably opposite the 2p glabellar lobes, as in the new species. The same illustration of *P. globosa* showed no anterior extension of the fixigenae beside, and overhung by, the anterior lobe. A whole exoskeleton identified by Ju (in Qiu *et al.* 1983) as *P. hubeiensis* Zhou (1974, p. 228, pl. 76, fig. 9) has since been put in synonymy with *P. nanjiangensis* Lu in Lu and Chang 1974 by Zhou and Dean (1986, p. 767). The specimen lacks the anterior lobe and shows both the large rostral plate and a forwards extension of the fixigenae, which are as wide as the posterior lobe. A median occipital tubercle occurs in at least one paratype of *P. pilula* and may be a general feature of *Paraphillipsinella*, though not clearly visible in all illustrations.

A subconcentric pattern of anastomosing, fine ridges on the anterior lobe of the glabella extends as subparallel, longitudinal ridges on the posterior lobe. On the holotype there is a suggestion of pits in some of the intervening grooves, an ornamentation generally resembling that found in *Phillipsinella* (Bruton 1976). Evidence for similar ridges in other species of *Paraphillipsinella* is equivocal or absent, but the holotype of *P. globosa* Lu in Lu and Chang (1974, pl. 53, figs. 8 and 9) shows rows of fine granules, apparently concentrically arranged. The slightly greater width (tr.) of the glabella at the 1p lobes in *P. globosa* also recalls that in some species of *Phillipsinella* (see Bruton 1976 for various illustrations).

Two incomplete pygidia show a general resemblance to the type species of *Phillipsinella*, *P. parabola* (Barrande 1846) from the Ashgill of Bohemia, redescribed by Whittington (1950, p. 559, pl. 75, figs. 4 and 7). One, a latex cast (Pl. 60, fig. 19), has the axis slightly abraded but there are traces of three axial rings; the pleural regions show three segments, separated by distinct rib furrows and carrying well-defined pleural furrows. The other, an internal mould (Pl. 60, fig. 7), has four segments and there are traces of ornamentation, comprising oblique, anastomosing ridges, similar to that figured by Bruton (1976, pl. 106, fig. 1; pl. 108, figs. 1, 5, 10, 12). Both Turkish pygidia have the posterior margin slightly indented medially and a marginal rim is weakly developed.

Family ASAPHIDAE Burmeister 1843
Subfamily ASAPHINAE Burmeister 1843
Genus BIRMANITES Sheng 1934

Type species. Ogygites birmanicus Reed 1915, from the Hwe Mawng Beds (Lower Ordovician), Hwe Mawng and Hpakhi, northern Shan States, Burma. The synonymy of the genus was discussed by Zhou *et al.* (1984, p. 17).

Birmanites latus (Angelin 1851)

Plate 61, figs. 3–7; Plate 62, figs. 1, 2, 4, 8

1851 *Niobe lata* Angelin, p. 14, pl. 10.
1960 *Opsimasaphus latus* (Angelin); Kielan, p. 78, pl. 6, figs. 1 and 2; pl. 7, fig. 3; pl. 8, fig. 4; text-fig. 20.
1981 *Opsimasaphus*; Dean, Monod and Perinçek, p. 277.

Figured specimens. It. 19545 (Pl. 61, fig. 3), It. 19546 (Pl. 61, fig. 4), It. 19547 (Pl. 61, fig. 5), It. 19548 (Pl. 61, fig. 6), It. 19549 (Pl. 61, fig. 7), It. 19552 (Pl. 62, fig. 1), It. 19553 (Pl. 62, fig. 2), It. 19554 (Pl. 62, fig. 4), It. 19555 (Pl. 62, fig. 8).

Localities. Şort Tepe, Z.33-4; Şort Dere, Z.34.

Description and discussion. Birmanites latus is easily the most abundant trilobite in the collections from the Şort Tepe Formation. The material agrees closely with the lectotype and other specimens from the Red *Tretaspis* Mudstones (Ashgill) of Västergötland, Sweden, described by Kielan (see synonymy above) and provides little additional information.

Some compressed cranidia (Pl. 61, figs. 4 and 7) appear to show strong sigmoidal ridges extending from the rear ends of the palpebral lobes, subparallel to the posterior branches of the facial suture, and ending about half-way to the posterior margin. These structures are the result of crushing and are not invariably developed. As in the lectotype cranidium, a large, low, median tubercle is sited just behind a line joining the rear ends of the palpebral lobes. The flanks of the tubercle carry about five or six narrow, subconcentric ridges and the apex has a trace of a small median perforation.

All the pygidia are dorsally compressed with median length slightly more or less than 0·6 of the breadth. The almost straight-sided axis has a frontal breadth about 0·2 that of the pygidium and occupies about 0·8 of its length, though the terminal piece is not well defined. Largest examples (Pl. 61, fig. 3) have at least eight, low, transversely straight axial rings, separated by shallow ring furrows, in the anterior four-fifths of the axis, the remainder being indiscernible. This matches closely Kielan's illustration (1960, pl. 6, fig. 2), where a further two rings and a tiny terminal piece are visible. The pleural fields show, in addition to the large anterior half-ribs, five pairs of ribs clearly defined and a sixth less so; this agrees with the original of Kielan 1960, pl. 6, fig. 1, though a better-preserved Swedish example (Kielan 1960, pl. 6, fig. 2) has six pairs of ribs and a less well-defined seventh pair.

Kielan did not describe the hypostoma of *B. latus* but two associated Turkish specimens (Pl. 62, figs. 1, 2) of asaphinid type are assigned to the species. Maximum breadth (including anterior wings) is about three-quarters the overall length, and the posterior margin is deeply indented to form a narrow, median notch with subparallel sides. Middle body is longitudinally subelliptical with length two-thirds that of hypostoma, and with curved posterior margin concave rearwards, subparallel to median notch; posterolateral extremities

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EXPLANATION OF PLATE 61

Figs. 1 and 2. *Diacanthaspis* sp. Loc. Z.34. 1, cranidium, It. 19542, ×6. 2, left librigena, It. 19543, ×6.

Figs. 3–7. *Birmanites latus* (Angelin 1851). Loc. Z.34. 3, pygidium, It. 19545, ×1·5. 4, cephalon, It. 19546, ×2. 5, ventral surface of pygidial doublure, It. 19547, ×5. 6, exfoliated pygidium showing doublure, It. 19548, ×2. 7, cranidium showing median tubercle, It. 19549, ×2·5.

Figs. 8–10. *Amphitryon*? sp. 8 and 9, loc. Z.34; 10, loc. Z.36. 8, cranidium, It. 19550, ×4. 9, cranidium, It. 19551, ×5. 10, front of cranidium showing anterior border, It. 19476, ×8.


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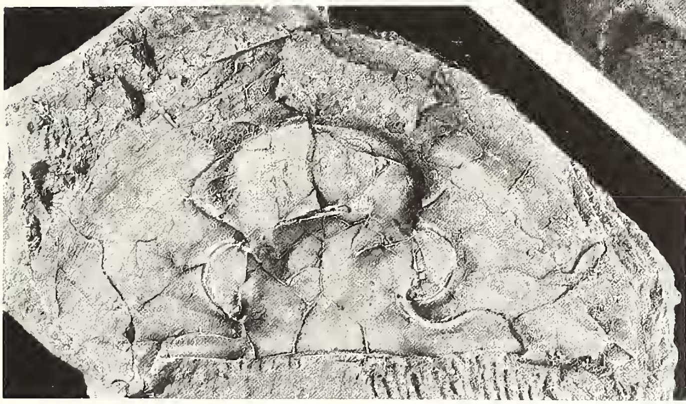
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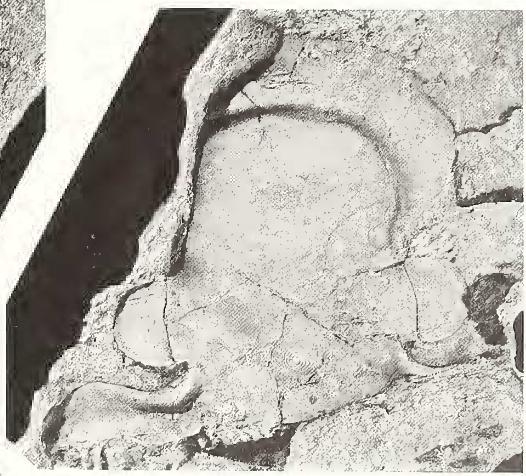
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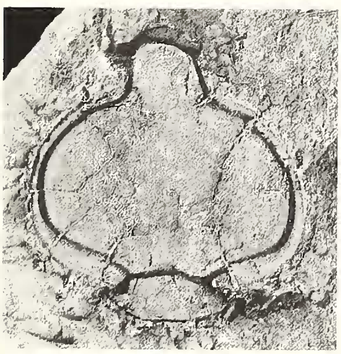
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9


10

DEAN and ZHOU, Turkish Ordovician trilobites

formed by pair of large maculae, bounded anterolaterally by deep, triangular furrows. Posterior borders are large, their lateral margins strongly curved, abaxially convex, linked by low ridges to anterior half of middle body. Frontal portion of hypostoma formed by flat anterior border that circumscribes middle body and widens (exsag.) distally to end in pair of short (tr.), obtusely angular anterior wings. Overall breadth across anterior wings slightly less than that across posterior borders, and the two structures are separated by broad (exsag.) lateral notches. Except for a few terrace lines around margin of posterior notch and on front of middle body, the surface is smooth.

The hypostoma of *B. birmanicus* has not been illustrated but that of *B. hupeiensis* Yi 1957, from the Shihtzupu Formation (Llandeilo) of Guizhou Province, China, was redescribed by Zhou *et al.* (1984, p. 17, fig. 3*f*). It differs from those attributed here to *B. latus* in having the middle body proportionately shorter and less elliptical in outline; posterior wings are longer and more pointed; median notch is conspicuously wider and longer (0·36 versus 0·25 of overall length of hypostoma), its sides converging forwards at 45° instead of being subparallel; and the anterior border, though not clearly visible, appears to be proportionately shorter.

Family AULACOPLEURIDAE Angelin 1854
Subfamily AULACOPLEURINAE Angelin 1854
Genus HARPIDELLA M'Coy 1849

Type species. *Harpes*? *megalops* M'Coy 1846, Upper Llandovery of Boocaun, Cong, County Galway, Ireland.

Harpidella sp.

Plate 60, fig. 22; Plate 62, fig. 6

Figured specimens. It. 19541 (Pl. 60, fig. 22), It. 19559 (Pl. 62, fig. 6).

Locality. Şort Dere, Z.34.

Description and discussion. This form is assigned to *Harpidella* on account of the large, posteriorly situated palpebral lobes, considered by Thomas and Owens (1978, p. 71) as an important character in distinguishing *Harpidella* from *Otarion* Zenker 1833. However, it also resembles the type species of *Otarion*, *O. diffractum* Zenker 1833 (see Thomas and Owens 1978, pl. 7, figs. 1–3, 5, 6), from the Kopanina Formation (Ludlow) of Dlouhá Hora, Czechoslovakia, in the narrow glabella, narrow (sag.) anterior border, faint palpebral furrows, and vaulted preglabellar field. The Turkish specimens are inadequate for satisfactory comparison but are generally similar to undetermined species of *Otarion* figured by Ingham (1970, pl. 5, fig. 12) from the Ashgill, Cautleyan Stage, of northern England and by Dean (1974, pl. 26, fig. 9) from the Chair of Kildare Limestone (Ashgill, Rawtheyan) in eastern Ireland, especially in the outline and size of the glabella, and in the small 1p glabellar lobes. Both these British and Irish species have large, backwardly placed palpebral lobes and are probably better referred to *Harpidella*.

EXPLANATION OF PLATE 62

Figs. 1, 2, 4, 8. *Birmanites latus* (Angelin 1851). 1, 2, 4, loc. Z.34; 8, loc. Z.33-4. 1, hypostoma, It. 19552, ×3. 2, hypostoma, It. 19553, ×3. 4, right librigena, It. 19554, ×2. 8, dorsal exoskeleton, It 19555, ×3.

Fig. 3. *Miraspis* sp. Loc. Z.34. Cranidium, It. 19556, ×7·5.

Fig. 5. *Stenopareia* sp. Loc. Z.36. Cranidium, It. 19558, ×5.

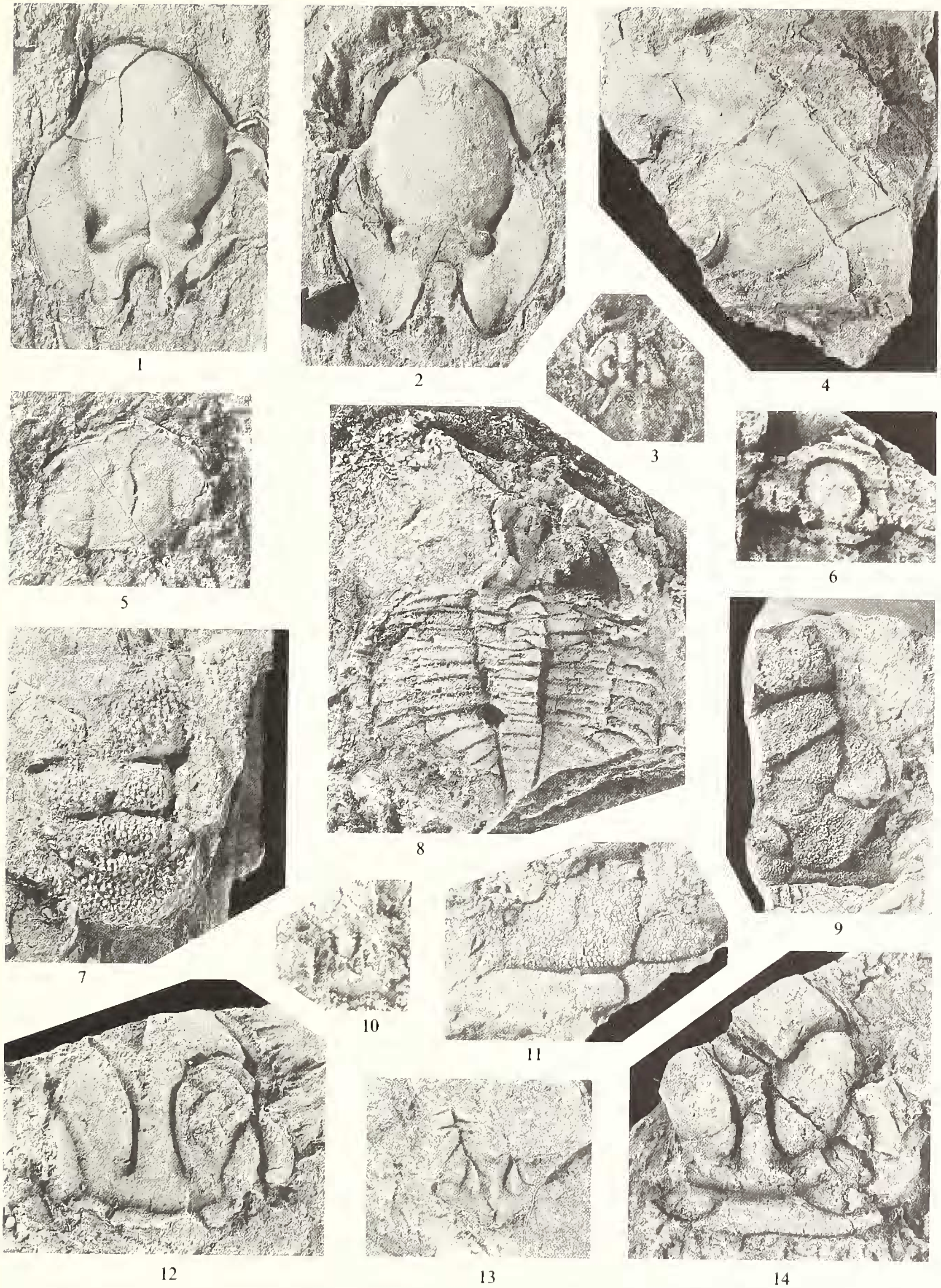
Fig. 6. *Harpidella* sp. Loc. Z.34. Cranidium, It. 19559, ×9.

Fig. 7. Genus and species undetermined. Loc. Z.34. Pygidium, It. 16062, ×3·5.

Figs. 9? and 13. *Dicranopeltis* sp. Loc. Z.34. 9, right side of cranidium, It. 19471, ×3·5. 13, pygidium, It. 19472, ×4.

Fig. 10. *Diacanthaspis* sp. Loc. Z.34. Pygidium, It. 19557, ×7.

Figs. 11?, 12, 14. *Lichas* aff. *laciniatus* (Wahlenberg 1821). Loc. Z.34. 11, fragment of cranidium, It. 19473, ×4. 12, cranidium, It. 19474, ×3. 14, cranidium, It. 19475, ×3.



DEAN and ZHOU, Turkish Ordovician trilobites

Family KOMASPIDIDAE Kobayashi 1935
Genus PHOROCEPHALA Lu in Lu *et al.* 1965

Type species. Phorocephala typa Lu in Lu *et al.* 1965, Siliangssu Formation (upper Arenig), Laingshan, south Shaanxi Province, China.

Phorocephala sp.

Plate 60, figs. 4 and 24

Figured specimens. It. 19528 (Pl. 60, fig. 4), It. 19529 (Pl. 60, fig. 24).

Locality. Şort Dere, Z.34.

Description. Cranidium about twice as long as wide. Glabella well defined by deeply incised axial furrows, its length 0·65 that of cranidium, slightly longer than wide, gently tapered forwards, rounded anteriorly. Occipital ring one-sixth the cranidial length (sag.), wider (tr.) than base of glabella, with posterior margin arched backwards; abaxial portions are narrower (exsag.) and curve forwards slightly to axial furrows. Fixigenae narrow, with width one-sixth that of cranidium as measured across mid-length of palpebral lobes. Palpebral lobes gently curved in plan and run slightly inwards anteriorly; their length is 0·45 that of cranidium and they extend almost to posterior border furrow. Anterior branches of facial suture subparallel; preglabellar area short, equal to one-sixth the cranidial length. Anterior border is dorsally convex, widens adaxially, and is defined by distinct, though shallow, anterior border furrow. Preglabellar field depressed, as long (sag.) as anterior border.

The pygidium is about twice as broad as long, its outline approximately lozenge shaped. The large, strongly tapered axis has a frontal breadth half that of the pygidium. There are two large, curved axial rings, convex forwards, with traces of a third; the pleural regions have a very thin, marginal rim and show two pairs of deep pleural furrows and two pairs of shallow rib furrows.

Discussion. The cranidium, though incomplete, is comparable with that of the type species, *P. typa* Lu (in Lu *et al.* 1965, p. 587, pl. 123, fig. 14; see also Lu 1975, pl. 34, fig. 13), in the shape of the glabella and the size and location of the palpebral lobes. According to Zhou and Dean (1986, p. 751) the preglabellar field of *Phorocephala* is absent in adult cranidia, though present in immature cranidia, of all known species of Caradoc and Ashgill age. The present specimen has a median length of only 2·3 mm and probably represents a juvenile individual.

The pygidium of the type species was not described by Lu but that of *P. shizipuensis* Yin (in Yin and Lee 1978) from the Llandeilo of Guizhou Province, China, figured by Zhou *et al.* (1984, fig. 5*x*, *z*) has an outline resembling that of the present specimen. Both have a large, triangular axis but in the Turkish species the pleural regions are proportionately smaller, with straighter margins, and there are only two pairs of pleural and interpleural furrows, compared with four.

Family REMOPLEURIDIDAE Hawle and Corda 1847
Genus AMPHITRYON Hawle and Corda 1847

Type species. Caphyra radians Barrande 1846, p. 32 (a senior subjective synonym of *Caphyra murchisonii* Hawle and Corda 1847), from the Králův Dvůr Formation (Ashgill), Králův Dvůr, Czechoslovakia.

Amphitryon? sp.

Plate 61, figs. 8–10

Figured specimens. It. 19550 (Pl. 61, fig. 8), It. 19551 (Pl. 61, fig. 9), It. 19476 (Pl. 61, fig. 10).

Localities. Şort Dere, Z.34 and Z.36.

Description and discussion. The most complete cranidium, though dorsally compressed, is apparently of low convexity with overall breadth of 9·0 mm and median length (including preglabellar field) of 9·8 mm. Cranidial length, excluding anterior tongue of glabella, is 7·2 mm, and basal breadth of glabellar tongue is 0.3 of maximum glabellar breadth. Glabellar outline closely resembles that of *Amphitryon radians* and the most obvious difference is the total absence of glabellar furrows in the Turkish material, though the value of this as a generic character is unknown. Whittington's (1966, p. 72, text-fig. 4*a–g*) illustrations of *A. radians* from Bohemia show three incised pairs of glabellar furrows, but the occipital ring and palpebral lobes are virtually indistinguishable from those of the Turkish specimen, and the glabellar tongue ends behind a triangular preglabellar field, the apex of which probably coincided with a median suture. The breadth (tr.) of the glabellar tongue as shown by Whittington equals only about 0·14 the glabellar breadth, but in material from Bohemia and Poland assigned to *A. radians* by Kielan (1960, pl. 2, figs. 3, 5, 6) the corresponding figure varies from 0·2 to 0·25, though a small Polish cranidium identified as *Amphitryon* sp. (Kielan 1960, pl. 3, fig. 12) has a very narrow glabellar tongue (only 0·13 estimated). It is possible that the relative breadth of the glabellar tongue changed during ontogeny, and for present purposes more importance is attached to the triangular preglabellar field, which readily distinguishes the Turkish specimens from *Remopleurides* (see account of type species *R. colbii* Portlock 1843 in Whittington 1950, p. 540).

Other species previously assigned to *Remopleurides* that have a triangular preglabellar field include the Chinese forms *R. nasutus* Lu 1957 (see Lu 1975, pp. 109, 299, pl. 3, fig. 15; pl. 4, figs. 5, 8, 9), from the Arenig of south Shensi and West Hupeh, and *R. shihtzupuensis* Lu 1957 (see Lu 1975, pp. 111, 301, pl. 4, fig. 15), from the Arenig to Llandeilo of North Kueichou and West Hupeh. *R. nasutus* has a wide glabellar tongue with rounded frontal margin and the triangular preglabellar field is shorter and less distinct than in the Turkish material; *R. shihtzupuensis* is closer to the latter in the shape of the preglabellar field but has a much longer glabellar tongue. *Sculptella* and *Sculptaspis* from the Middle Ordovician of Norway (Nikolaisen 1982, pp. 265, 276) bear a superficial resemblance to the present material but their cranidia lack the triangular preglabellar field.

Family ILLAENIDAE Hawle and Corda 1847
Genus STENOPAREIA Holm 1886

Type species. Illaenus Linnarssoni Holm 1882, Boda Limestone (Ashgill Series), Dalarne, Sweden.

Stenopareia sp.

Plate 62, fig. 5

Figured specimen. It. 19558.

Locality. Şort Dere, Z.36.

Description and discussion. The Turkish cranidium is too compressed for specific identification, but the form of the axial furrows and the width of the fixigenae are consistent with those of *Stenopareia linnarssoni*, redescribed by Warburg (1925, p. 117, pl. 2, figs. 14–18), though the position of the eyes is not clear.

Family LICHIDAE Hawle and Corda 1847
Subfamily LICHINAE Hawle and Corda 1847
Genus LICHAS Dalman 1827

Type species. Entomostracites laciniatus Wahlenberg 1821, from the *Dalmanitina* Beds (Ashgill) of Bestorp, Mösseberg, Sweden.

Lichas aff. *laciniatus* (Wahlenberg 1821)

Plate 62, figs. 11?, 12, 14

Figured specimens. It. 19473 (Pl. 62, fig. 11), It. 19474 (Pl. 62, fig. 12), It. 19475 (Pl. 62, fig. 14).

Locality. Şort Dere Z.34.

Description and discussion. Two cranidia, slightly distorted by dorsal compression, show clearly the composite lateral lobes incompletely defined posterolaterally as in *Lichas laciniatus*, redescribed by Warburg (1925, p. 295, pl. 8, figs. 16, 17, 20; 1939, p. 15, pl. 9, fig. 3*a*, *b*). The occipital lobes are also similar and the palpebral lobes correspond in size and location. The long axes of the composite lateral lobes diverge forwards at about 45°, comparable with Warburg's illustrations, but the median lobe narrows to half the breadth of the composite lobes; this contrasts with *L. laciniatus*, where the median and composite lobes are of equal breadth in larger specimens, though one small cranidium (Warburg 1925, pl. 8, fig. 17) has the median lobe slightly narrower. The narrowest part of the median lobe is also much narrower than that of the neotype of *L. affinis* Angelin, 1854, from the Ashgill of Sweden (Warburg 1939, pl. 9, fig. 13). The glabella in the Turkish material is relatively shorter than that of *L. laciniatus* (length : breadth = 34 : 34 versus 38 : 34), the occipital ring is proportionately narrower (exsag.), especially distally, and the occipital lobes are notably larger. *L. laciniatus* ranges from the Ashgill into the Llandovery Series and cranidia from northern England described by Temple (1969) correspond to the Swedish material.

Genus DICRANOPELTIS Hawle and Corda 1847

Type species. Lichas scabra Beyrich 1845, upper part of the Liteň Formation (Wenlock), Svaty Jan, near Beroun, Czechoslovakia.

Dicranopeltis sp.

Plate 62, figs. 9? and 13

Figured specimens. It. 19471 (Pl. 62, fig. 9), It. 19472 (Pl. 62, fig. 13).

Locality. Şort Dere, Z.34.

Description and discussion. The Turkish pygidium generally resembles material from the Ashgill (Boda Limestone and *Dalmanitina* Beds) of Sweden described by Warburg, first as *Dicranopeltis elegans* (Törnquist 1884) (Warburg 1925, p. 291, pl. 7, figs. 27 and 31; pl. 8, figs. 9 and 10), and later put in synonymy with *D. polytomus* (Angelin 1854) (Warburg 1939, p. 134, pl. 11, figs. 4–6). *D.* sp. differs from the pygidium of *D. polytomus* in having a less sharply constricted terminal piece, and the axial furrows are moderately convergent to what is essentially a low, slightly tapered post-axial ridge, separated by a pair of very shallow grooves from the extremities of the third pleurae, which end in short free points separated by a very small median notch. The third pleurae of the Turkish pygidium occupy a relatively smaller area and the equisized pleural bands end in rounded tips at the broad border. The entire surface, except furrows, is covered with closely spaced, small tubercles that become slightly smaller on the posterior border. The rearmost part of the axis, immediately in front of the post-axial ridge, is bulbous as in the Swedish material.

The sole, possibly associated cranidial fragment is crushed and the position of some furrows apparently displaced, so that the composite lateral lobes appear more divergent forwards than originally, and the palpebral lobe has been displaced towards the glabella. The occipital ring and right occipital lobe resemble those of *D. polytomus*, but the rearmost part of the axial furrow is almost indiscernible, in marked contrast to the well-defined furrow in the Swedish species.

Family ODONTOPLEURIDAE Burmeister 1843
Subfamily ODONTOPLEURINAE Burmeister 1843
Genus DIACANTHASPIS Whittington 1941

Type species. Diacanthaspis cooperi Whittington 1941, Lower Martinsburg Formation (Caradoc), Virginia, USA.

Diacanthaspis sp.

Plate 61, figs. 1 and 2; Plate 62, fig. 10

Figured specimens. It. 19542 (Pl. 61, fig. 1), It. 19543 (Pl. 61, fig. 2), It. 19557 (Pl. 62, fig. 10).

Locality. Şort Dere, Z.34.

Description and discussion. Cranidium has parallel-sided glabella with wide, subparallel-sided median glabellar lobe and narrow, elongated 1p and 2p lateral glabellar lobes. It agrees well with the cranidium of *D.* sp. of Lu and Zhou (1981, p. 20, pl. 3, fig. 10) from the Tangtou Formation (low Ashgill) of the Nanjing Hills, China. In each case the cranidium is incomplete, and no associated pygidium is available for the Chinese form, so that specific identity cannot be established. Occipital spines are not preserved on the Turkish specimen, though a prominent median tubercle is present close to the occipital furrow. Another species of *Diacanthaspis* with parallel-sided glabella is *D. laokuangshanensis* Lu and Chang (1974, p. 136, pl. 56, figs.

5–7), from the Wufeng Formation (Ashgill) of western Sichuan, China, but the lateral glabellar lobes are wider (tr.) and the median lobe expands forwards.

A fragmentary Turkish librigena shows a flat, coarsely granulate genal field and small, raised eye socle. Lateral border is narrow, ridge-like, with marginal spines that become successively shorter (tr.) anteriorly.

The pygidium has a semicircular outline and a convex axis comprises two axial rings and short terminal piece. Pleural field narrow (tr.), weakly defined by narrow border of low convexity. There are five equispaced pairs of slender, radiating border spines, whereas in all other known species of *Diacanthaspis* there are six or more pairs.

Subfamily MIRASPIDINAE R. and E. Richter 1917
Genus MIRASPIS R. and E. Richter 1917

Type species. Odontopleura mira Barrande 1846, from the Liteň Formation (Wenlock), Lodenice, Czechoslovakia.

Miraspis sp.

Plate 62, fig. 3

Figured specimen. It. 19556.

Locality. Şort Dere, Z.34.

Description. Glabella tapers gently forwards, its basal breadth half that of cranidium. It is transversely convex with elongated, subrectangular median lobe that expands abruptly to form very short frontal glabellar lobe. Three pairs of lateral glabellar lobes well defined by deep longitudinal furrows; 1p lobes oval in outline, their width equal almost to that of median glabellar lobe and to 0·4 of glabellar length; 2p lobes sub-square in plan, slightly narrower than 1p lobes; 3p lobes tiny, transverse, with length (exsag.) one-quarter that of 2p lobes. Three pairs of almost transverse lateral glabellar furrows present; 1p and 2p furrows deeply incised, 3p pair shallow. Occipital furrow shallow, broad; anterior part of occipital ring with median tubercle and pair of long, broadly based spines that extend upwards posterolaterally; posterior part of occipital ring not preserved. Axial furrows distinct posteriorly, shallow anteriorly. Fixigenae narrower posteriorly than 1p lobes, and become still narrower further forwards. Palpebral lobes situated opposite mid-points of 1p lobes. Sutural and palpebral ridges slightly convex abaxially and converge forwards. Anterior border as narrow as palpebral ridges, and defined by shallow preglabellar furrow. Cranidial surface covered with densely spaced tubercles of different sizes.

Discussion. The cranidium, though imperfectly preserved, is compatible with that of the lectotype of *Miraspis mira* (Barrande 1852, pl. 39, fig. 3, selected by Přibyl in Horný and Bastl 1970, p. 203) and of a well-preserved dorsal exoskeleton of that species figured by Prantl and Vaněk (in Horný *et al.* 1958, pl. 5, fig. 1) but differs in having the median glabellar lobe narrower, with straighter sides, while the 1p and 2p glabellar furrows are more distinct abaxially.

Ordovician species of *Miraspis* have been recorded from Sweden (Whittington and Bohlin 1958; Bruton 1966), Norway (Owen and Bruton 1980), eastern Ireland (Dean 1974), North Wales and Scotland (Whittington and Bohlin 1958, p. 43). In the shape of the cranidium and median glabellar lobe and in the pattern of surface granulation the Turkish specimen resembles *M.* sp. of Owen and Bruton (1980, p. 36, pl. 10, figs. 18 and 20), from the uppermost Solvang Formation (probably low Ashgill) of Ringerike, Norway, but the latter has shallower 1p and 2p glabellar furrows and the 2p glabellar lobes are proportionately much smaller.

Genus and species undetermined

Plate 62, fig. 7

Figured specimen. It. 16062.

Locality. Şort Dere, Z.34.

Description and discussion. A fragmentary internal mould, interpreted tentatively as part of a pygidium, has the surface, excluding furrows, covered with coarse, closely spaced tubercles. The ornamentation bears some resemblance to that of the odontopleurids, and there is some evidence of one of a pair of subparallel ridges ending in line with the first axial ring; in the odontopleurids similar ridges link the corresponding ring with a pair of large marginal spines. Three markedly unequal axial rings, separated by transversely straight ring furrows that deepen abaxially, are followed by a minute, weakly defined terminal piece and gently declined postaxial field. No satisfactory comparison was made.

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